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Fluid-dynamic device

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The invention relates to a fluid-dynamic device of the type specified in the introduction to claim 1.

From the field of sailing boats a number of bodies of the above-mentioned type are known which comprise two sailcloth portions resembling conventional airfoil profiles in cross section. These profiles cause the air force component across the direction of flow to be greater than for a standard single sailcloth. In order to obtain a sail with such a wing profile, highly complicated devices have hitherto been employed including, e.g. a number of straps, walls, cords etc. extending between the sail portions. The known sails are therefore expensive, heavy and complicated, thus making a holder for the sail, i.e. both the standing and running rig, equally heavy and expensive, while the sail is awkward to use.

The object of the invention is to provide a device of the above-mentioned type which is inexpensive, lightweight, of simple design and easy to use.

This object is achieved with a device according to the invention with the characterising features indicated in claim 1. Characteristic features of embodiments of the device for the invention will be apparent in the dependent claims.

The invention will now be described with reference to the figures which schematically illustrate advantageous embodiments of the device according to the invention, where the body, for example, is a sail and the holder is a rig on board a boat.

Fig. 1 is a view of a wing profile.

Fig. 2 is a perspective view of a single sailcloth portion, foil or the like, which is rectangular in top view and is influenced by a stretching or tensile force.

Fig. 3 is a perspective view of two sailcloth portions of the type illustrated in fig. 2, which are interconnected, each of the sailcloth portions being influenced by a stretching force.

Fig. 4 is a perspective view of the double sailcloth or sailcloth assembly illustrated in fig. 3, which is supported by a holder, where the sailcloth assembly forms a wing, and a fluid, e.g. air flows against the wing at an angle of attack relative to the wing.

Fig. 5 is a perspective view similar to that illustrated in fig. 4, where the sail assembly is triangular in a side view like a Bermuda sail and is supported by a holder, such as a mast mounted on a boat sailing on the port tack.

Fig. 6 is a perspective view similar to that illustrated in fig. 5, but where the sail's position is illustrated by dotted lines when the boat is heading straight into the wind, and by solid lines when the boat is sailing on the starboard tack.

Fig. 7 is a side view of a boat with a substantially triangular sail where a luff of the sail extends close against a heavily curved mast.

Fig. 8 is a side view of what is illustrated in fig. 7, but where the mast extends in a less curved manner.

Fig. 9 is a side view of a mainsail in a position where the sail's tack corner is located at a distance from the mast, the sheet corner having been tightened towards the free end of a boom.

Fig. 10 is a side view of a jib whose luff in a first position illustrated by a dotted line extends for its whole length along the forestay, and in a second position illustrated by a solid line extends at its lower portion at a distance from the forestay.

Fig. 11 is a side view of a triangular sail, e.g. a jib, whose luff and after leech are suspended in a headboard and in the lower parts can be stretched downwards and released alternately, the rope connected to the lower end of the leech that is not stretched downwards acting as a sheet.

Figs. 12 and 13 illustrate two cross sections through respective embodiments of a body according to the invention.

The invention is based on knowledge of the fact that birds which are adapted to a life of essentially continuous hovering with the least possible consumption of energy, such as an albatross, which can soar for up to 1000 km during a 24-hour period, have wings with a wing profile similar to the profile 1 illustrated in fig. 1.

This profile 1 resembles a standard airfoil profile, but is very heavily curved and very thick at its front portion. The windward side of the profile, i.e. the side facing the reader, is substantially symmetrical about a vertical centre line M, apart from at the profile's front portion, and the windward side's largest outward bend is located near the centre line M. The leeward side is clearly asymmetrical about the centre line M. In the front portion a nose circle 10 may approximately be inscribed.

The invention is further based on the sequence or first effect illustrated in fig. 2. In this figure a rectangular sailcloth portion 2 is illustrated, which extends in a plane P. The sailcloth portion 2 has a leading edge 3 and a trailing edge 4. At a distance from the leading edge 3, the sailcloth is influenced by two opposite, equal forces K1, K2 with a force line LV which extends parallel to the leading edge. On account of internal sailcloth stresses S1, S2, S3, which have been caused by the forces K1, K2, and have components extending across the force line LV in a sailcloth area 6

between the force line LV and the leading edge 3, the sailcloth material is pulled towards the force line, thus causing a raising of the leading edge 3 and a curving of the sailcloth. A curve of this kind can be supported by a highly flexible connecting element such as a lath 5, which can be connected to the sailcloth. It may, for example, be connected to one of the sides of the sailcloth, be located in a pocket thereof and supported against end bottoms of the pocket, or it may be woven into or otherwise inserted in the sailcloth, the batten 5 being relatively resistant to breaking. By this means the formation of more bends of the leading edge against the force line may be avoided, the sailcloth area 6 being in the form of one single bend with regular curvature. The lath 5 may extend over only a front area of the sailcloth portion 2 or over its entire length, considered in the direction of flow.

A first effect of this kind can be reinforced, e.g. by a sailcloth portion with a convexly curved leading edge which has been reinforced, e.g. by folding the leading edge or by a cord extending along it which is fixed to the leading edge. This reinforcement can absorb a greater part of the tightening force and components of this part that extend across the line LV attempt to pull the leading edge towards this line.

By providing an additional sailcloth portion 7 whose leading edge and trailing edge are connected to the leading edge 3 and the trailing edge 4 respectively of the sailcloth portion 2, and stretching the sailcloth portions 2, 7 as illustrated in fig. 3, a sailcloth assembly can be obtained where both sailcloth portions 2, 7 are curved to the same extent towards each other, thus forming a front, curved sailcloth area 9. This sailcloth assembly 8 therefore has a cross section approximately in the form of a symmetrical airfoil profile. From figs. 2 and 3 it will be seen that the length of the area 6 of the sailcloth portions 2, 7 located in front of the force line LV may approximate to at least a fourth of the circumference of the nose circle.

A body or sailcloth assembly 8 of the type illustrated in fig. 3 may be mounted in a holder 11 as schematically illustrated in fig. 4, where a couple of opposite tightening forces K1 and K2 are exerted by portions 12, 13 of the holder against the sailcloth assembly 8 at its leading edge. These forces are transferred to the respective sailcloths via suitable means, such as reinforcing pieces or the like which, e.g. are sewn into the sailcloth portions. Other holder portions 14, 15 may be arranged mainly only for support of the sailcloth assembly at its trailing edge 4. A fluid flow may flow against the sailcloth assembly 8 with a velocity V at an angle relative to an extension C of a wing profile chord. The sailcloth portion 7, i.e. the sailcloth portion on the windward side of the profile according to the figure, is thereby influenced by fluid at a raised pressure and pushed in a direction towards the sailcloth portion 2 located on the leeward side. Fluid at a greater velocity than the velocity V flows past the sailcloth potion 2 on the leeward side of the profile, thereby causing it to be sucked away from the sailcloth portion 7. Thus by merely

tightening the sailcloth portions in the above-mentioned manner and by the influence of the wind a sailcloth assembly is obtained with a highly curved profile similar to that illustrated in fig. 1.

Due to a second effect, viz. that the fluid flow attempts to push the leading edge 3 in the downstream direction, the front sailcloth area 9 is compressed, thus further increasing the thickness of the wing profile.

A body or sailcloth assembly comprising two triangular, similarly shaped sailcloth portions is illustrated in fig. 5, this sailcloth assembly being approximately in the form of a pointed bag. The end that forms the top or point of the sailcloth assembly is attached by suitable means to a holder via a holding portion 16, and holding portions 17, 18 are similarly connected by suitable means to the respective corners of the sailcloth assembly at its leading edge 19 and its trailing edge 20 respectively.

The holder may comprise a mast 25 and a boom 26 of a boat 27, the forward direction being indicated by F. The body or sailcloth assembly therefore resembles a Bermuda sail and will hereinafter be called a sail.

Air flows against the sail at a relative wind velocity V1 and at an angle of attack relative to a profile chord for the sail, and the boat 27 according to fig. 5 is sailing on the port tack.

Fig. 6 is a perspective view similar to that illustrated in fig. 5, but where the sail's position is illustrated by dotted lines when the boat is heading straight into the wind, as indicated by the arrow V2, and the sheet is not tightened. The sail's position is illustrated by solid lines when the boat is sailing on the starboard tack and the wind direction is as indicated by the arrow V3.

When the sheet is not tightened and the sail can move freely, the profile of the sail is symmetrical. Thus in the case of a boat which has luffed into the teeth of the wind and no forces are exerted on the sail via the sheet, a sail of this type shows no tendency to be pulled to the sides or to flap from side to side. It therefore remains substantially at rest with its centre plane parallel to the wind direction and in the position illustrated by dotted lines in fig. 6. This has been confirmed in practice and is a great advantage, since the boom also remains still. There is therefore no danger of people being hit and possibly pushed overboard by a boom in motion, and the boat is easier to steer, particularly in a strong wind, e.g. when luffing to a buoy for mooring. It seems a likely possibility that the flapping of the sail in a sidewise direction also results in a greater air resistance and consequently a corresponding loss of height during tacking.

Fig. 7 is a side view of a boat 40 with a mast 41 supporting a triangular double sail 42 according to the invention, i.e. a sail with two overlapping triangular sailcloth

portions. The sail has a luff 43 and an after leech 44. According to the figure the mast 41 extends in the space 39 between the sailcloth portions 45, 46 of the sail 42, but does not need to do so. In order to provide a variable tightening of the mast so as to give it a variable curvature along the boat's longitudinal plane, a tightening line 49 is provided between an upper point on the mast near the top 47 of the mast and a lower point 48 at the lower end of the mast 41.

In the position of the mast 41 and the sail 42 illustrated in fig. 7, the line 49 is tightened to such an extent that the sail's leading edge or the luff 43 is adapted to the curvature of the mast 41 and extends along it.

If the sail has this shape in an unloaded state and the sail is not loaded, the sailcloth portions 45, 46 will not bulge out, in which case the sailcloth portions are located close together apart from in the area near the mast where they extend round it. The sail thereby has a shape approximating that of a standard single cloth sail.

In the case of the relative position of the mast and the sail illustrated in fig. 8, however, the line 49 has been slackened and the mast has therefore straightened up. Thus its curvature has been reduced and the top of the mast has been raised a distance h. Since the sail's leading edge previously extended along the more heavily curved mast according to fig. 8, a front area 50, 51 of the respective sailcloth portions 45, 46 of the sail is located in front of the mast 41 after the mast has been straightened. A part of the tensile force originally borne by the line 49 has thereby been transferred to the sailcloth portions 45, 46, since the force line for the force exerted against the sailcloth portions extends between the upper end 52 and the lower end 53 of the luff 43, i.e. in this case near the line 49. The front areas 50, 51 of the respective sailcloth portions 45, 46 are thereby forced to assume a curvature and extend in a curved form towards each other, giving the sail a profile corresponding to a wing profile due to the above-mentioned, first effect. Furthermore, the sail's leading edge is pushed backwards by the wind and the front area is further thickened due to the second effect.

To assist in moving the front areas 50, 51 away from each other, thus preventing them from extending in an undulating fashion during the tightening of the sail, connecting elements such as laths 54, 55 may be provided to stretch out the sailcloth portions, i.e. they attempt to move the luff away from a point located behind, e.g. the after leech, i.e. substantially along a wing profile chord. Connecting elements of the respective sailcloth portions may attempt to move the sailcloth portions away from each other, and the connecting elements may, e.g., be elastically interconnected in pairs at the luff 43.

Elements of this kind may be provided on the sides of the sailcloth portions facing each other, i.e. on the side facing in towards the space 39 between the sailcloth portions, on the outside of the sailcloth portions or in pockets provided in each

sailcloth portion. The elements may be woven into or otherwise inserted in the sailcloth portions 45, 46 or they may extend freely in the space 39 by being connected to the sailcloth portions at the latter's leading edge and behind it, possibly at the trailing edge of the sailcloth portions. The elements preferably have so little rigidity that they do not need to be removed even though the sail is reefed by being wound up on, e.g. the mast. The connecting elements 54, 55 may extend over only the front sail areas 50, 55 or continue towards or extend all the way to the trailing edge 44. A combination of such connecting elements may be provided.

In each of the sailcloth portions 45, 46 and, e.g. near the luff, there may advantageously be provided at least one admission opening 56, 57 for admitting air from the side of the sail which momentarily forms the overpressure side, i.e. the windward side of the sail, thus enabling this air to help to keep the sailcloth portions 45, 46 apart from each other. At least one discharge opening 58 may also be provided, e.g. at the after leech 44, for discharging air from the space 39 between the sailcloth portions. On the inside of the openings 56, 57 at the luff and possibly also the opening 58 at the after leech, there may be provided flap valves or the like (not shown) which may be variable, thus providing valves that offer the possibility of varying the air pressure in the space 39 between the sailcloth portions 45, 46. The openings 56, 57 may, e.g. act as non-return valves which let air in but not out, where the flaps can be moved towards or away from the openings under the influence of a pressure differential over the openings. During an operation of the device according to the invention, air can therefore, e.g., flow freely into the body through the openings arranged on the sailcloth side which momentarily is the windward side (the overpressure side), while the openings arranged on the leeward side (the underpressure side) are closed. Excess air in the body may be discharged, e.g., through the opening 58 at the after leech.

The admission opening is preferably arranged and formed in such a fashion that it can maintain its function even though the sail is reefed by being partially wound up on the mast. This can be achieved, e.g., by the admission opening being elongated in a direction across a wind-up axis, as indicated in fig. 8. The discharge opening at the sail's trailing edge may be formed by the sailcloth portions here being interconnected apart from at the location of the discharge opening.

The sailcloth portions 45, 46 may instead be sealingly interconnected along all outer edges, not including any openings of the above-mentioned type. In this case the inner space 39 may instead be arranged to be connected to the surrounding air via at least one stop valve 59 which is only schematically illustrated. Before a tightening of the sail 42, the stop valve 59 may be open. During a tightening of the sail, therefore, air can flow into the space 39 via the stop valve 59 in order to permit a movement of the sailcloth portions away from each other. When the sailcloth

portions have reached their desired final position, the valve 59 can be closed, whereupon the volume of the space 39 is maintained when sailing.

In order to facilitate a reefing of the sail by winding it up on the mast, it is advantageous for the laths to extend at an acute angle relative to the mast's longitudinal direction.

The sail may comprise a suitable combination of laths 54, 55, a valve 59, openings 56, 57 and/or the opening 58.

The two sailcloth portions need not be similar in shape. Thus the sail may comprise a first and a second sailcloth portion, where the first sailcloth portion is narrower than a second, considered in the sail's chord direction. According to fig. 8, therefore, the trailing edge of the first sailcloth portion may extend along a dotted line 60. A discharge opening 58' may then be formed by the trailing edge of the first sailcloth portion being sealingly connected to the second sailcloth portion apart from at the location of the discharge opening 58'.

Fig. 9 is a side view of a mainsail 72 with a luff 73 and an after leech 74. The sail is double, comprising two sailcloth portions 75, 76 in the same way as the above-mentioned sails. The sail 72 is held by a mast 77 and a boom 78, where, e.g., a leech rope of the sail runs in grooves in the mast and the boom. By means of cords or the like, a tack corner 79 can be moved along the boom 78 between a front location 81 near the mast 77 and a rear location 82 at a distance from the mast 77.

The mast 77 has only a small curvature. If the tack corner 79 is at the front location 81, the force line for a force exerted between a headboard 83 and the tack corner 79 therefore extends substantially linearly and near the luff. Thus no bends or only a small bend is essentially formed in the front portion of the sailcloth portions 75, 76.

However, if the tack corner 79 is pulled backwards to the rear location 82, the force line 84 extends for a greater distance from the luff 73 and bends may be formed in the front area of the sailcloth portions, so that the sail's profile can assume the shape of a wing profile as explained above. The sheet corner 85 can also be pulled backwards to help with adjustment of the bending.

If the leading edge of the sail is convex in the forward direction and has a greater curvature than the mast when the sail, e.g., is only lying unfolded on a flat floor, the mast will exert a force in its transverse direction against the sail when the sail has been hoisted without having been tightly stretched, the effect hereby created by the mast resembling the above-mentioned second effect, which is created by wind and which attempts to make the sail's leading edge blunter. When in addition the sail is tightened, it is exposed to both the first and the second effect, with the result that the front area of the sail's wing profile becomes very thick.

With an increase in wind the mast will become increasingly curved in the known manner, thus extending forwards in a more noticeably convex fashion. The sail will thereby be influenced to a lesser extent by the mast and assume a flatter form, which is advantageous in a strong wind.

Possible cross sections of the sail at different heights of the sail are indicated in the figure. In addition, cross sections are indicated when the boat (not shown) on which the sail is mounted is sailing on the port tack or starboard tack, or is luffed into the wind.

If there is mounted in the upper part of the mast an upper boom which is rotatably connected to the mast like the boom 78, and which can be held projecting out on the mast 77, the headboard 83 can be supported by the upper boom, and the headboard 83 and the adjacent, upper portion of the luff can be moved from or towards the mast in the same way as the tack corner 79 and the portion of the luff near it. Instead of the sail being triangular and its upper end pointed, the upper edge of the sail can be adapted to the length of the boom, with the result that it may, e.g., be trapezoidal, rectangular or the like. With sails of this kind, moreover, a tightening device may be provided at the upper boom for the upper, front corner and possibly the upper, rear corner of the sail, this device being of similar design to the tightening device for the tack corner 79 and the sheet corner 85, and capable of being operated from the boat deck. The force line for the tightening forces may be caused to extend, e.g., at regular intervals from the mast.

The device for moving the tack corner 79 and possibly similarly the upper, front corner of the sail may provide control of wrinkling and bellying of the sail at the mast, also for a single cloth sail.

Fig. 10 is a side view of a jib 92 whose luff 93 is attached to a forestay 97 and whose after leech 94 runs freely. The jib has two sailcloths 95, 96 like the above-mentioned sails.

The jib 92 is illustrated in two positions, viz. a first position, where the jib is indicated by solid lines, and in a second position, where the jib is indicated by dotted lines. In the second position the jib 93 extends for its entire length along the forestay, a lower end 98 of the jib 93 being located close to the forestay 97. In the first position the lower end 98 and the upper end of the luff are located at a distance from the forestay 97.

As will be understood from the above, the front portion of the jib 92 will be curved and the jib's cross section will assume the shape of a wing profile when a force line 99 for a tightening force exerted between the lower end 98 of the luff 92 extends at a distance behind the luff 92.

In this figure there are also depicted different jib cross sections of the jib when the boat (not shown) on which the jib is mounted is sailing on the starboard or port tack respectively and luffed into the wind. In the latter case the cross section is symmetrical.

The bottom of the forestay may be connected to the boat via a device 100 whereby the jib can be rolled up on the forestay 97 for reefing the jib.

By slackening the forestay, the object may be achieved of causing it to extend concavely, viewed in the forward direction. The sail may thereby assume the shape in cross section of a wing profile which is thickened at the leading edge, also in the case of sails whose leading edge in an unloaded state extends rectilinearly.

Fig. 11 is a side view of a triangular sail 102 with two sailcloth portions 105, 106 like the above-mentioned double sails. The sail 102 has a first edge 103 and a second edge 104. The sail is stretched at its corners, where forces are exerted as indicated by the arrows K1-K4, the force K1 and its reaction force K2 being exerted along a first force line 125, and the force K3 and its reaction force K4 being exerted along a second force line 126. The sail 102 is arranged to be brought into a first air flow with a relative wind direction V4 or a second air flow with a relative wind direction V5. The force line 125 is located downstream relative to the first edge 103 when the sail is brought into the first air flow. The force line 126 is located downstream relative to the second edge 104 when the sail is brought into the second air flow.

Near its upper corner, i.e. the corner which in the figure faces away from the reader, the sail 102 may have an eye 111 or the like via which the forces K1 and K3 can be transferred to the sail 102 from a holder (not shown).

In order to exert the forces K2 and K4, the sail 102 may have lines 112 and 114 respectively which are indicated by dotted lines.

When the sail 102 is brought into the first air flow and forces K1 and K2 are exerted, the line 112 acts as a downhaul line or a short forestay for continuous tightening of the sail 102, and the line 114 acts as a sheet.

At the first edge 103 which hereby forms an upstream edge, therefore, areas of the sailcloth portions 105, 106 according to the above-mentioned first effect are moved away from each other and curved in such a manner that the cross section of the sail resembles the cross section of a wing.

On account of the above-mentioned second effect, the fluid flow also attempts to force the first edge 103 in the fluid flow direction, thereby as an additional effect attempting to make this blunter in shape, i.e. move the sailcloth portions 105, 106 further from each other in the front sailcloth area, with the result that the wing

profile here obtains a further increase in thickness, which is advantageous. The first edge 103 will hereby be slightly straightened, with the result that it extends closer to the force line 125. A wing profile of this type is indicated by reference numeral 116 where a boat (not shown) on which the sail is mounted, is sailing on the starboard tack. A profile 117 is also depicted where the boat is sailing on the port tack and a profile 118 where the boat is luffed into the wind respectively. When no tension forces or wind forces are exerted against the sail, it has a profile 119.

When the sail 102 has been brought into the second air flow and forces K3 and K4 are exerted, the line 114 acts as a downhaul line or a short forestay, and the line 112 acts as a sheet. The sailcloth portions 105, 106 are thereby moved away from each other at the second edge 104. Profiles corresponding to the above-mentioned profiles while sailing on different tacks are indicated by the reference numerals 121 and 122, while a profile that is obtained when the boat is luffed into the wind is indicated by the reference numeral 123. The reference numeral 120 indicates a profile for a sail which is not influenced by tension or wind forces.

Fig. 12 is a schematic illustration of a cross section through an embodiment of a body 141 according to the invention. The contour of this cross section resembles the extremely advantageous wing profile illustrated in fig. 1. The body has two sailcloth portions 131, 132 whose trailing edges E1, E2 are interconnected. The sailcloth portion 131 of the body 141 which according to the figure is located on the windward side of the body 141 is substantially symmetrical about a centre line M and has its greatest outward bending or outward curvature at this centre line M. The leeward sailcloth portion 132 is asymmetrical relative to the centre line M and has its greatest outward curvature relatively far forward. From a point near the centre line to the trailing edge, the two sailcloth portions may abut against each other, e.g. depending on the profile's curvature.

Figure 13 illustrates a cross section through a second body 142 comprising a windward sailcloth portion 133, and a leeward sailcloth portion 134. For comparison, the leeward sailcloth portion 132 according to fig. 12 is indicated by a dotted line.

By means of this body 142 according to the invention the trailing edge E3 of the windward sailcloth portion 133 is connected to the trailing edge E4 of the leeward sailcloth portion at the ends of the body, i.e., e.g., at the ends located at the upper and lower parts of a mast respectively. The remaining trailing edge areas of the sailcloth portions therefore have the possibility of sliding relative to and towards one another in the event of wind load on the body from different sides. Connecting devices may be provided to hold the sailcloth portions against one another substantially without preventing them sliding relative to one another, e.g. by their interconnection via elastic connecting elements such as elastic bands. The rear end

of the leeward sailcloth portion can thereby move from the point indicated by E4 to the point indicated by E4', and the leeward sailcloth portion 134 can assume the extremely favourable shape illustrated in fig 13. The object is achieved here that the length of the leeward side is increased relative to the length the profile would have had if sliding of the sailcloth portions relative to one another had not been possible.

The fluid-dynamic device according to the invention has been described above with the body and the holder in the form of a sail and a mast, boom and/or stay of a boat respectively, and where air can flow around the sail.

It will be appreciated, however, that the device according to the invention may be employed in connection with any kind of fluid and together with any kind of device, where the body is required to exert a force with a component which is directed across or at an angle relative to the fluid's direction of flow.

Thus the device according to the invention may, for example, be employed as wings for aircraft, particularly for very light aircraft. Each wing may hereby be designed, e.g. like the sailcloth assembly illustrated in fig. 9, where the holder is in the form of a projecting, cylindrical rod, protruding sideways from the vessel's hull and preferably extending into the space between the sailcloth portions. The rod is preferably rotatable, thus enabling the sailcloth assembly to be rolled our wound up on the rod.

On start-up of the aircraft, the sailcloth assembly may be wound off the rod, thereby giving the wing a maximum area. Even with a low relative air velocity, therefore, the lifting force may be very great. When the relative air velocity gradually increases, the rod may be rotated and the sailcloth portions wound up on the rod, thus reducing the wing area while maintaining the lifting force.

In order to increase the load capacity, the space between the sailcloth portions may be filled with a gas which is lighter than air, e.g. helium.

A device according to the invention may also be employed, e.g., in connection with a power station, where the sailcloth assembly may be sails of, e.g., a windmill or blades of a turbine for exploitation of a water current such as a tidal current. In this context it may be advantageous to employ a device according to, e.g., fig. 11, where the sailcloth assembly can be adapted to water currents which at different times of the day and night flow towards the sailcloth assembly in opposite directions. When winding up the sailcloth assembly, it can be adapted to different current velocities.